

# Benefits of Effective SO<sub>3</sub> Removal in Coal-Fired Power Plants: Beyond Opacity Control

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## Summary

Emissions of SO<sub>3</sub> (or its hydrated form, H<sub>2</sub>SO<sub>4</sub>) have received increasing attention due to the widespread application of and aggravating effects of SCR and wet FGD technologies. While the emphasis of this attention has been on plume opacity and buoyancy, it should be recognized that SO<sub>3</sub> has significant impacts on plant performance, operations, and maintenance for all coal-fired power plants - from acid dew point considerations limiting heat recovery and causing backend corrosion, to reacting with ammonia and fouling air heaters, to deactivating SCR catalyst, to competing with mercury for active adsorption sites on carbon particles.

The quick and efficient removal of SO<sub>3</sub> from coal-fired power plant flue gases, i.e., defined for the purposes of this paper as reducing SO<sub>3</sub> emissions to 3 ppm or less prior to the gas entering the air heater, can produce a host of valuable benefits over and above the elimination of plume opacity or buoyancy issues related to sulfuric acid aerosol emissions. SO<sub>3</sub> concentration determines the acid dew point of the gas. When any surfaces in contact with the flue gas cool below the acid dew point, sulfuric acid condenses, causing corrosion. Removing SO<sub>3</sub> efficiently can result in a dew point suppression of 50 to 70F, which can eliminate acid corrosion in the backend of the power plant. In addition, this creates the opportunity to recover additional heat in the air heater, with potential improvement of heat rate on the order of 1 to 2%. Decreasing the gas temperature exiting the air heater reduces gas volume, benefiting ESP performance and I.D. fan energy requirements.

If SO<sub>3</sub> is efficiently removed upstream of the air heater, ammonia slip from the SCR will not result in ammonium bisulfate (ABS) fouling of the air heater. Flexibility to allow modest increases in ammonia slip can significantly improve SCR NO<sub>x</sub> removal efficiencies, generate saleable NO<sub>x</sub> credits, and provide valuable flexibility in SCR design, operations and catalyst management program. Eliminating ABS fouling potential can allow SNCR technology to achieve higher NO<sub>x</sub> removal efficiencies and, perhaps, broaden its applicability to higher sulfur fuels. If SO<sub>3</sub> can be captured effectively, then SCR catalyst design, specifically SO<sub>2</sub> to SO<sub>3</sub> oxidation, can be viewed as an economic variable. Higher activity catalyst types can be reevaluated for increased NO<sub>x</sub> removal capabilities and higher mercury oxidation potential. If flexibility exists for SCRs to achieve higher NO<sub>x</sub> removals, then reducing the degree of combustion staging to control NO<sub>x</sub> formation in the boiler can be considered, allowing the SCR to remove any additional NO<sub>x</sub> generated. By reducing the combustion staging, heat rate improvements can result from reductions in unburned carbon and fireside corrosion can be substantially reduced. Any improvements in heat rate will result in reduced carbon dioxide emissions. With utilities facing increasing pressure to reduce CO<sub>2</sub> emissions, effective SO<sub>3</sub> removal can play a significant role in achieving CO<sub>2</sub> reductions of from 1 to 3% for coal-fired power plants.

SO<sub>3</sub> is adsorbed onto flyash and competes with mercury for these active sites. Retention of mercury by flyash has been shown to be enhanced in the absence of SO<sub>3</sub>. If SO<sub>3</sub> is removed effectively before the gas cools, flyash will retain more mercury, and most importantly, the performance of activated carbon technology can be significantly improved. Also, the capacity of activated carbon to remove mercury is enhanced as the gas temperature is reduced, which can also be accomplished without corrosion implications if SO<sub>3</sub> is removed. Thus, the effective removal of SO<sub>3</sub> can play a role in improving mercury removal strategies for both high-sulfur (via SCR mercury oxidation enhancement with downstream collection in the FGD system) and low-sulfur (by improving the performance and economics of activated carbon) coals.

For these benefits to be realized, of course, the SO<sub>3</sub> removal technology must be efficient, reliable and operate without negative balance of plants impacts. SO<sub>3</sub> removal also involves capital and operating expenses. However, the value of many of the benefits noted above taken individually could offset the entire operating cost of SO<sub>3</sub> removal; the cumulative value could easily exceed the cost of SO<sub>3</sub> removal by several factors.

None of this discussion is meant to diminish in any way what may perhaps be the most valuable benefit of effectively eliminating sulfuric acid aerosol emissions – that of changing the perception of the public that burning coal is environmentally unacceptable. Individual power plants have invested hundreds of millions of dollars in capital costs and annually spend millions to control emissions of particulates, SO<sub>2</sub> and NO<sub>x</sub>, and yet the presence of very small amounts of SO<sub>3</sub> can cause the stack plume to exhibit a visual discoloration that can extend for many miles. The effective removal of SO<sub>3</sub> will eliminate any health or opacity impacts of sulfuric acid aerosol emissions and is certainly in the long-range interests of the utility and coal industries. To do this in a manner which creates benefits in excess of the costs of removing the SO<sub>3</sub> is a very worthwhile, accomplishable goal that benefits both industry and the public.